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Short-lived climate pollutant mitigation and the sustainable development goals

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The post-2015 development agenda is dominated by a set of Sustainable Development Goals (SDGs) which arose from the 2012 Rio+20 UN Conference on Sustainable Development. The agreed 17 goals and 169 targets address diverse and intersecting aspects of human and environmental needs and challenges. Achieving the SDGs by 2030 requires implementing coordinated and concerted strategies and actions that minimize potential trade-offs and conflicts and maximize synergies to contribute to multiple SDGs¹.

Measures to mitigate emissions of short-lived climate pollutants (SLCP) are an example of actions that contribute to multiple outcomes relevant to development ^{2,3}. This paper highlights the interlinkages between SLCPs and the SDGs and shows that implementing SLCP emissions reduction measures will contribute to achieving many of the SDGs.

1.0. Mitigating SLCPs

SLCPs are agents that contribute to warming but have relatively short lifetimes in the atmosphere - a few days to a few decades –consequently harmful concentrations of SLCPs can be reduced in a matter of weeks to years, resulting in near-term benefits. Many SLCPs are also powerful air pollutants which are significant contributors to premature death and chronic illness globally and harm the environment. The main SLCPs are black carbon, methane, tropospheric ozone, and hydrofluorocarbons (HFCs) (Figure 1).

A number of recent studies have identified specific technical and policy measures which if implemented globally can achieve multiple benefits by reducing emissions of SLCPs and their co-emitted pollutants²⁻⁸. The various SLCP emissions reduction measures and potential impacts of the measures on the SDGs are outlined in table 1. Examples are discussed below.

Figure 1

Table 1

2.0. Linking SLCP mitigation to the SDGs

Goal 1: No Poverty

SLCP measures can indirectly contribute to Target 1.1 to cut poverty in half by, for example, reducing household expenditures on energy. The poorest and most vulnerable members of society are often the most dependent upon dirty and polluting fuels to supply their basic cooking, heating and lighting needs. They often spend a substantial percentage of their income purchasing these fuels or significant time collecting fuels, which reduce time for income generating activities (Goal 8). Measures to address HFCs⁹, to supply modern efficient cooking and heating stoves, and to replace kerosene lamps with modern lighting can improve household incomes by reducing energy costs (Goal 3). SLCP measures can also indirectly benefit Goal 1 by reducing vulnerability and near-term impacts of climate change (see Goal 13), improving public health (Goal 3), supporting food security and farm incomes (Goal 2), driving innovation and job creation (see Goal 8), and reducing gender inequalities (Goal 5).

Goal 2: Zero Hunger

By 2030 SLCP mitigation can avoid the loss of above 50 million tons of four staple crops annually – maize, rice, soybean and wheat -from exposure to ground level ozone concentrations (Figure 2)². Ozone pollution is the major cause of crop yield loss from air pollution, and could reduce global yields of these four staple crops between 3-16%¹⁰. Thus, SLCP measures contribute to Target 2.3 which aims to double agricultural productivity and incomes of small-scale food producers.

Ground-level ozone can also alter the nutritional value of some plants and vegetables^{11,12}, which impacts Targets 2.1 and 2.2 to end hunger and malnutrition. Decreased pasture quality in terms of the metabolisable energy content of the vegetation can lead to a potential total reduction in lamb production. In the UK this could amount to approximately 4% in 2020 compared to 2007¹¹, resulting in reduced income generation (Goal 1). Improvements in refrigeration energy efficiency through HFC measures can also contribute to Targets 2.1 and 2.2 by increasing the affordability of refrigeration and reducing food waste (Target 12.3). Furthermore, measures such as intermittent aeration of continuously flooded rice paddies, farm-scale anaerobic digestion of manure from cattle and pigs, and banning of open field burning of agricultural waste, can contribute to Target 2.4 by improving sustainable agricultural production¹³.

Finally, climate change is projected to adversely impact crop yields, particularly in low latitude regions through changes in temperature and rainfall patterns¹⁴. SLCP strategies increase crop yields through the reduction of ozone concentrations and warming (Goal 13), and SLCP measures appear to offer greater potential benefits compared with CO₂ reduction during the next several decades^{2,14}.

Goal 3: Good Health and Well-Being

Outdoor (ambient) and household fine particulate matter (PM_{2.5}) air pollution, is a major source of ill-health globally and is estimated to be responsible for between 5.5 to 7 million premature deaths annually caused by strokes, heart disease, lung cancer, chronic obstructive pulmonary disease (COPD), and acute lower respiratory infections (ALRI)¹⁶⁻¹⁸. SLCP measures such as reducing diesel engine emissions, and increasing use of clean public transport, together with active travel (walking and cycling) can directly and indirectly improve public health by reducing outdoor air pollution exposure and increasing physical activity². SLCP measures can contribute directly to achieving Target 3.9 to reduce the numbers of deaths from pollution by preventing around 2.4 million outdoor air pollution-related deaths annually by 2030^{2,3}.

Millions of additional lives can potentially be saved by reducing sources of household air pollution (HAP). Globally close to 3 billion people still rely on traditional cooking and heating methods using solid

biomass and fossil-fuels and many millions rely on kerosene wick lamps, which are major sources of black carbon and HAP^{6,18}. Due to their traditional household responsibilities in many cultures, women and children suffer from a higher level of exposure to HAP, in comparison to men. Approximately 60% of HAP related deaths globally occur in women and children (Goal 5) including more than half of all pneumonia deaths in children under the age of 5 years¹⁸. Measures to reduce HAP, can thus contribute to Target 3.9 and Target 3.2 to end preventable deaths of newborns and children under 5 years of age as well as 3.4, to reduce premature mortality from non-communicable diseases (NCDs).

Finally, adopting diets that conform to WHO guidelines, can reduce methane emissions, while also improving health – through reduced NCD risks (3.4)– largely due to increased consumption of vegetables, fruit, nuts and seeds and decreased consumption of animal products (particularly red and processed meat) in high consuming populations¹⁹. Dietary change and reduction in food waste can also reduce emissions from CO₂ and N₂O (fertilizer application for feed crops, land use change, energy to produce fertilizer, etc.)

Figure 2

Goal 4: Quality Education

A number of SLCP measures can indirectly support Goal 4 by reducing poverty, HAP, improving public health, and increasing education opportunities²⁰. Access to modern energy and lighting is important to support education. Clean cooking and heating measures can increase time for education, particularly for girls (see Goal 5), by reducing time spent collecting fuel; these and HFC measures can also support educational opportunities by reducing household fuel costs and supporting poverty reduction (Goal 1). School-aged children also suffer from a high burden of ill-health due to HAP(Goal 3), which contributes to missed school days (as does ambient air pollution) and lowered educational outcomes.

Eliminating kerosene for lighting can indirectly support education by reducing household fuel costs, and also directly by improving the quality of light available for studying²⁰. A typical kerosene wick lantern produces 0.7% of the illumination recommended for reading and as little as 0.1% of the light produced by an equivalent LED lantern²¹.

Goal 5: Gender Equality

Women and children are often responsible for fuel collection. This limits time available to engage in income-generating activities (Goals 1 & 8), or in the case of children, to focus on education (Goal 4). This also places them at greater risk of injury or gender-based violence outside the home²². For these reasons, measures to provide modern cooking, heating, and lighting can benefit Target 5.2 by reducing violence against women and Target 5.5 by affording greater opportunities to participate equally in political, economic, and public life.

Goal 6: Clean Water and Sanitation

SLCP measures could help improve water availability and quality for the estimated 663 million people lacking access to improved drinking water sources globally and at least 1.8 billion people without reliable access to potable water²³. For example, in areas where sewerage and waste water treatment infrastructure is already in place, upgrading secondary/tertiary sewerage and waste treatment to collect and utilize methane can support Target 6.3 to halve the proportion of untreated wastewater. Using composting toilets may produce much lower methane emissions than pit latrines and can be economically competitive with other methane measures in organic waste sectors²⁴.

SLCP measures can also improve access to water resources by increasing rainfall in regions where drought and water shortages are projected to occur²⁵, or where black carbon-loaded pollution causes a significant shift in the distribution of rainfall towards heavier downpours²⁶.

Goal 7: Affordable and Clean Energy

SLCP mitigation measures offer numerous opportunities for improving energy access. For example, the recovery and utilization of methane from coal mines, from the oil and gas sector, and landfills and wastewater treatment plants offer alternative fuel for energy generation, contribute directly to Target 7.1 on ensuring universal access to modern energy, while also contributing to resource-use efficiency (Goal 12). This will also contribute to income generation (Goal 8) - one estimate suggests that about 30 billion dollars in revenue is lost worldwide due to methane leakage from oil and gas facilities²⁷.

Many SLCP measures also directly contribute to Target 7.3 to double global energy efficiency. Measures to modernize brick kilns, coke ovens, and introduce clean cooking and heating alternatives all improve facility and equipment efficiency. Furthermore, simultaneous transitioning to low-GWP refrigerants along with mechanical improvements in energy efficiency in room air conditioning could save between 340 and 790 gigawatts (GW) of peak power load globally²⁸. Reducing energy demand will also reduce energy-related air pollution (Goal 3), and CO₂ emissions (Goal 13) for a given population.

Goal 8: Decent Work and Economic Growth

Many SLCP measures support Goal 8 by decoupling economic growth from environmental degradation through the promotion of more efficient technologies, entrepreneurship and decent job creation. For example replacement of traditional brick kilns and coke ovens with modern facilities support Target 8.2 by promoting high efficiency technologies and practices and Target 8.4 by decoupling of economic growth from environmental degradation. A recent analysis of the brick industry in India found that transitioning to modern kilns could reduce coal consumption by up to 5 million tonnes per year with concomitant reductions in air pollution (Goal 3) and CO₂ emissions (Goal 13) as well as improving profitability of brick enterprises and working conditions²⁹.

HFC measures also support efficiency improvements, for example, recent case studies using low-GWP refrigerants have shown energy savings of up to 30% for refrigeration in commercial food stores³⁰. HFC measures can also support Target 8.3 by driving innovation and decent job creation³¹.

The replacement of traditional biomass cooking and heating stoves with more efficient alternatives will also improve resource efficiency and reduce deforestation (Goal 15). Cooking and heating stove projects can also support Target 8.3 by creating opportunities for job creation and entrepreneurship³². Finally, capturing and utilization of methane from coalmines alongside good safety practices will reduce the risk of methane-related explosions³³, thereby promoting safe and secure working environments (Target 8.8).

Goal 9: Industry, Innovation and Infrastructure

SLCP measures can contribute to Target 9.4 aimed at upgrading infrastructure and retrofitting industries to make them sustainable. For example, replacing traditional brick kilns and coke ovens results in the adoption of cleaner, more energy efficient, and environmentally friendly technologies (Goal 8). HFC measures can also foster innovation as companies compete to manufacture better products⁹.

SLCP measures can also protect infrastructure by slowing the rate of sea-level rise by approximately 18% by 2050³⁴. The impact of rising oceans, will impact key sectors in coastal and island states, including water resources (Goal 6), agriculture (Goal 2), and infrastructure, and will increase vulnerability of coastal communities (Goal 11) and their citizens (Goal 1) to flooding and storm surges.

Goal 11: Sustainable Cities and Communities

Today, more than half of the world's population lives in cities and 88% of cities worldwide fail to achieve the WHO guideline levels for air pollution³⁵. SLCP measures can directly contribute to Target 11.6 to reduce the adverse environmental impact of cities by significantly reducing urban air pollution, improving public health, saving lives (Goal 3), and encouraging municipal waste management.

Clean cooking, heating, and lighting measures and improving appliance efficiency through HFC measures support Target 11.1 to ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums by reducing household fuel costs (Goal 1), providing affordable clean energy (Goal 7), and reducing HAP (Goal 3). Measures to reduce diesel engine emissions and support active travel directly support Target 11.2 on safe, affordable, accessible and sustainable transport systems.

Goal 12: Responsible Consumption and Production

Measures to reduce fugitive methane emissions from the oil and gas sector, from coal mines, and farms, and municipal solid waste directly contribute to Target 12.4 to achieve environmentally sound management and minimize adverse impacts on human health and the environment (Goals 2 and 3). HFC measures in the refrigeration sector can help achieve Target 12.3 which aims to halve per capita global food waste at the retail and consumer levels, and can also contribute to food security (Goal 2). Municipal solid waste measures, including separation and treatment of biodegradable waste, can also support Target 12.5 through prevention, reduction, recycling and reuse.

Goal 13: Climate Action

Damages due to climate change are already upon us, affecting health and livelihoods, especially the poorest and most vulnerable. Furthermore, climate change is expected to increase the intensity and frequency of extreme events³⁶. These impacts hamper the achievement of national development priorities, threaten to reverse many of the hard fought improvements in public health, poverty reduction, education, and other development indicators, and put into peril the success of all SDGs.

Implementing SLCP measures with simultaneous deep cuts in CO₂ emissions, increases the likelihood of meeting the 2°C or less target in the 21st century. Mitigation of SLCPs can significantly reduce the rate of warming and protect against the increasing impacts of climate change during the near-term period relevant to the post-2015 development agenda³⁷. Mitigation of SLCPs could help avoid 0.6°C temperature rise by 2050^{2,4} and can cut the rate of global warming in half^{2,3}. Significant mitigation of CO₂ is crucial to avoid later warming and decarbonisation of the world economy is needed during this century

Reducing the near-term rate of warming can contribute directly to Target 13.1 by allowing more time for ecosystems and human societies to adapt. A decrease in the rate of near-term global warming also can decrease intensity and frequency of extreme weather events³⁸, which have been identified as important causes of poverty (Goal 1)³⁹ and reduce the rate of sea-level rise³⁴ (see above Goals 9 & 11)..

A number of SLCP measures can also directly and indirectly reduce CO₂ emissions through, for example, improvements in efficiency and therefore reduced energy and fuel use in a range of sectors. Promoting active travel and clean public transport can reduce fossil fuel emissions by reducing vehicle use. Reducing household woodfuel use can also reduce emissions from deforestation and protect carbon forest stocks (Goal 15).

Goal 15: Life on Land

. Collecting fuelwood and making charcoal particularly in Least Developed Countries⁴⁰ constitute the second most important driver of forest degradation after timber extraction, responsible for about 31% of forest degradation globally⁴¹. SLCP measures such as clean cooking and heating stoves can support Target 15.2 on sustainable management of forests and halting deforestation by reducing or eliminating domestic solid fuel use.

3.0. Implementing the SDGs

Implementing SLCP mitigation measures can contribute to the achievement of multiple SDG targets. As countries seek to incorporate SDG implementation into their national policy and planning processes, it is important that multiple benefits are assessed to identify actions and strategies that can help achieve several SDG targets, while minimizing conflicts and trade-offs. For most SLCP measures, there are synergies, often between many different SDGs and their targets. SLCP mitigation is complementary to CO₂ mitigation; many SLCP mitigation strategies can yield CO₂ mitigation co-benefits⁷ and vice versa.

The significant role that SLCP mitigation can play in achieving multiple SDGs suggests a need to develop nationally-relevant SLCP-specific indicators. SLCP mitigation could also be a thematic area of focus in SDG implementation to mobilize stakeholders and resources for action.

The Climate and Clean Air Coalition to Reduce Short Lived Climate Pollutants (CCAC) is a partnership among countries, intergovernmental and non-governmental organizations with a secretariat in UNEP which has the goal of catalyzing action towards the reduction of SLCPs⁴². The CCAC can provide guidance and institutional support both for developing national level indicators and for implementing identified strategies through its 7 sectoral and 4 cross cutting initiatives. These include the SNAP (Supporting National Action and Planning on SLCPs) initiative that helps partners in building capacity and strengthening institutions with the ultimate goal of helping them embed SLCP nationally appropriate mitigation strategies and actions in their policies. Prioritisation of mitigation strategies will depend on national development objectives, an emission inventory, barriers to implementation and available technologies, together with the availability of finance. Priority setting is part of the implementation of national planning by countries involved in the SNAP initiative. Our paper provides a framework to inform this and other decision making by making linkages to the SDGs.

To capitalize on the inherent synergies between SLCP mitigation and the SDGs, it will be important to quantify the multiple benefits of SLCP mitigation policies, whilst addressing potential trade-offs, using standardized methodologies. Targeted efforts to communicate these multiple benefits to decision makers are needed to incentivize deep cuts in SLCPs, for example through the Nationally Determined Contributions under the UNFCCC and regional air pollution cooperation initiatives (e.g., the Regional Action Plan for Intergovernmental Cooperation on Air Pollution in Latin America and the Caribbean). The SDGs offer a powerful mechanism to address climate and development imperatives simultaneously and integrating SLCP mitigation into the implementation of the SDGs can yield many benefits.

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	Selected SLCP Reduction Measures	Development Goals and Targets Benefited	Potential for trade-offs and conflicts
	Methane Measures	Achievement of G2 - Zero Hunger, and G3 - Good Health and Well-Being, will benefit from reduced ozone air pollution; G13 benefits from reduced climate forcing. In addition, specific targets benefiting are listed below.	
1	Pre-mine degasification and recovery, and oxidation of methane from ventilation air from coal mines	7.1 - ensure universal access to affordable, reliable and modern energy services; 8.4 - improve progressively, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation; 8.8 - promote safe and secure working environments; 9.2 - promote inclusive and sustainable industrialization; 9.4 - upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency; 12.4 - achieve the environmentally sound management of chemicals and all wastes throughout their life cycle.	no significant trade-offs identified
2	Recovery and utilization of gas and unintended fugitive emissions during oil and gas production	7.3 - double the global rate of improvement in energy efficiency; 8.4;9.2;9.4;12.4	as above
3	Reduce leakage from long-distance natural gas transmission pipelines and distribution systems	7.3;8.4;9.2;9.4;12.4	as above
4	Separation and treatment of biodegradable municipal waste and landfill gas collection	7.3;8.4;9.4; 11.3 -enhance inclusive and sustainable urbanization; 11.6 - reduce the adverse per capita environmental impact of cities; 12.4	as above
5	Upgrade wastewater treatment with gas recovery	6.3 - improve water quality by reducing pollution, ..., halving the	as above

	and overflow control	proportion of untreated wastewater and substantially increasing recycling and safe reuse globally; 9.2;9.4;11.3;11.6;12.4	
6	Livestock anaerobic digestion - cattle and pigs	2.4 - ensure sustainable food production systems and implement resilient agricultural practices that increase productivity; 7.1;8.4;9.2;9.4;12.4	as above
7	Intermittent aeration of continuously flooded rice paddies	2.3;2.4;12.4	There may be trade-offs between N ₂ O emissions and CH ₄ emissions depending on rice paddy water-management practices.
Black Carbon and Co-Pollutant Measures		G2&G3 both benefit from reduced BC pollution G13 benefits from reduced climate forcing	
8	Improve diesel vehicle emission standards (EURO VI) and diesel particulate filters (DPF) for on- and off-road vehicles	1.4 - ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services ...new technology etc.; 3.4 - reduce by one third premature mortality from non-communicable diseases through prevention etc.; 3.9 -substantially reduce the number of deaths and illnesses from hazardous chemicals and air pollution etc.; 11.2 - provide access to safe, affordable, accessible and sustainable transport systems for all; 11.6	DPF reduces vehicle efficiency and hence increases CO ₂ emission slightly, but is offset by more efficient modern engine technology (EURO VI). Electric and hybrid vehicles bring additional air pollution and CO ₂ emission benefits.
9	Replace traditional cooking and heating stoves with clean burning modern fuel stoves	1.1 - eradicate extreme poverty for all people everywhere; 1.4;3.2 - end preventable deaths of newborns and children under 5 years of age; 3.4;3.9; G4 - Ensure inclusive and equitable quality education; 5.2 - Eliminate all forms of violence against all women and girls; 5.5 - Ensure women's full and effective participation and equal opportunities for leadership; 7.1;7.3;11.1;11.6;15.2 - promote the implementation of sustainable management of all types of forests,	Replacing solid fuels with LPG results in minor CO ₂ emissions, but in areas where fuelwood collection reduces C stores in forests, the difference from using fuelwood are likely to be minimal.

		halt deforestation etc.	
10	Eliminate high-emitting on- and off-road diesel vehicles	1.4; 3.4;3.9;11.2;11.6	see DPF discussion and potential financial barriers to purchasing cleaner vehicles may increase inequities.
11	Replace traditional brick kilns and coke ovens with modern high-efficiency technologies	3.4; 3.9;7.3;8.4;9.2;9.4	no significant trade-offs identified
12	Ban open-field burning of agricultural waste	2.3 - double the agricultural productivity and incomes of small-scale food producers; 2.4; 3.4; 3.9	Some increase in pests, but outweighed by increase in organic matter in soils.
13	Replace kerosene wick lamps with modern clean lighting technologies	1.1;1.4;3.2; 3.4;3.9;G4;7.1;11.1 ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums; 11.6	Higher initial purchasing cost for solar lighting, but cost over longer term lower.
14	Eliminate gas flaring	3.9;9.2;9.4	
15	Promote active travel	1.1;3.4;11.2;11.6	May be some increase in road injuries but improved road safety policies can minimise trade-offs.
16	Promote healthy diets	1.4; 3.4;12.3	Some communities e.g. pastoralists depend on livestock for nutrition and livelihoods and need special consideration to avoid conflicts between SDGs. Children may benefit from consumption of animal products.
HFC Measures		G2 (through improved refrigeration); G13	
17	Simultaneously replace high-GWP HFCs with low-impact alternatives and super-efficient appliances and equipment	1.1;7.1;7.3;8.3;8.4;11.1;11.6;12.3;12.4	no significant trade-offs identified

Table 1 - SLCP mitigation measures identified in UNEP/WMO (2011); Xu et al. (2013) and Carvalho et al. (2015)^{2,4,5}, with assessment of possible trade-offs and conflicts between different SDGs and their targets. Other measures as identified in other publications include eliminating kerosene wick lighting (Lam et al., 2012)⁶, reducing black carbon from flaring in oil and gas facilities (AMAP, 2015)⁸ and supporting active travel aided by rapid mass transit and promoting healthy diets (WHO/CCAC, 2015)⁷.

SHORT-LIVED CLIMATE POLLUTANTS

Near term response to mitigation

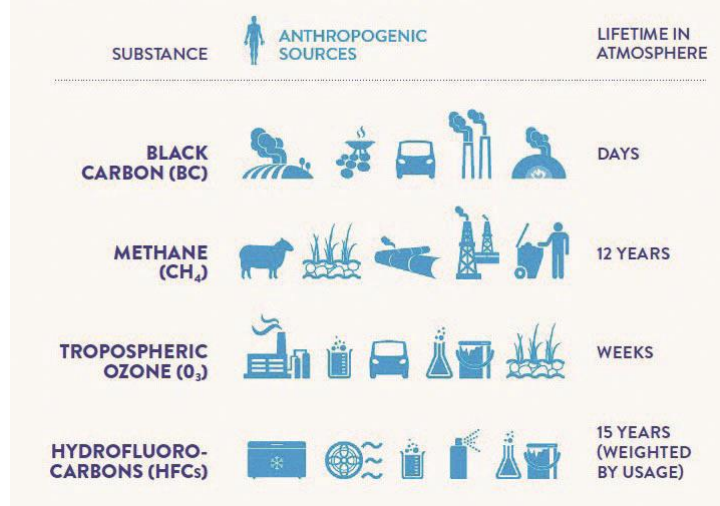


Figure 1: Short-lived climate pollutants,

major emissions sources, and atmospheric lifetimes. Black carbon is released from agricultural (residue burning), residential (cooking, heating and lighting), transportation (diesel engines), industrial (e.g., brick kiln, flaring in oil and gas facilities), and industrial (coke oven) sectors. Methane is emitted from agricultural (livestock production), agricultural (rice cultivation), oil and gas (transmission and distribution), oil and gas (production and refining), and waste management sectors. Tropospheric ozone is not directly emitted but formed by sunlight-driven oxidation of other precursor agents emitted industrial, chemical, vehicle, paints and solvents, and agricultural sources. HFCs are used in refrigeration, air conditioning, solvents, spray aerosols, and foam blowing agents. Source CCAC <http://www.ccacoalition.org/>



Figure 2 - Estimated annual benefits by 2030 from SLCP mitigation. Source CCAC <http://www.ccacoalition.org/>

